Measurement of In Situ Sediment Properties at the ONR/DRI Site

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LONG-TERM GOAL

My long goal with this project is to understand the chemical, geological and biological processes that control the physical properties of shallow water marine sediments. The physical properties of particular interest are those that are determined by grain-grain interactions, specifically including compressional wave velocity, attenuation and the permeability to fluid flow.

OBJECTIVES

In order to pursue the above goals, it became necessary to develop an instrument that can make accurate in situ measurements of the following parameters in the upper part of the sediment column; (1) compressional wave velocity at a variety of frequencies (velocity dispersion), (2) attenuation of acoustic waves, (3) in situ density, and (4) permeability to fluid flow. With the measurements of these critical in situ physical properties, it will then be possible to correlate this data with related parameters determined by other investigators over the same survey areas, including surface roughness, sediment grain petrology, porosity, total organic carbon content and bacterial cell counts and polymer density, and pore water content and chemistry. Observed correlations between these parameters within the two data sets can constrain any possible relationships between acoustic properties and the causative processes.

APPROACH

We have developed an instrument that has the capability of measuring the in situ compressive wave velocity, density and permeability of sand for the upper part of the sediment column. This instrument will be deployed in conjunction with the ONR/DRI field program in the summer of 1999, off-shore of Panama City, Florida. This instrument is a large (3 meter base by 3 meter high) tripod that uses a hydrojet to insert a sensor probe to a 1 meter depth into sandy sediments. Multiple sound sources (3.5 khz and 12 khz) are used to measure compressive wave velocity and attenuation as a function of depth within the sediment column. A Ce-137 radioactive source and scintillation counters are used to measure gamma ray backscatter, for direct sediment density measurements. These in situ density measurements will be combined with the sand grain densities from recovered samples to obtain sediment porosities. Finally, the existing fluid pumping system on the tripod will be used to generate overpressure within the undisturbed portion of the sediment column, and the spatial decay of this overpressure (measured with sensitive differential pressure gauges) is a quantitative measure of the sediment permeability.

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WORK COMPLETED

The basic tripod was completed in fiscal year 1998, with successful dock tests on both the hydrojet insertion technique and the acoustic systems. In April, 1998, we conducted a critical field test, deploying the tripod on a sandy bottom at the Duwamish Head (in Puget Sound). This field test was very successful, with a full 1 meter insertion of the probe into sand. Acoustic measurements were also successfully made, using the real-time data link to the ship. These new data indicated that acoustic attenuation measurements were a real possibility with this system (a capability that was not certain prior to the tests). Software for instrument control and data acquisition were also successfully tested during this field program. These data and the overall status of the equipment were reported at the ONR/DRI meeting in Stennis, Mississippi in May, 1998.

RESULTS

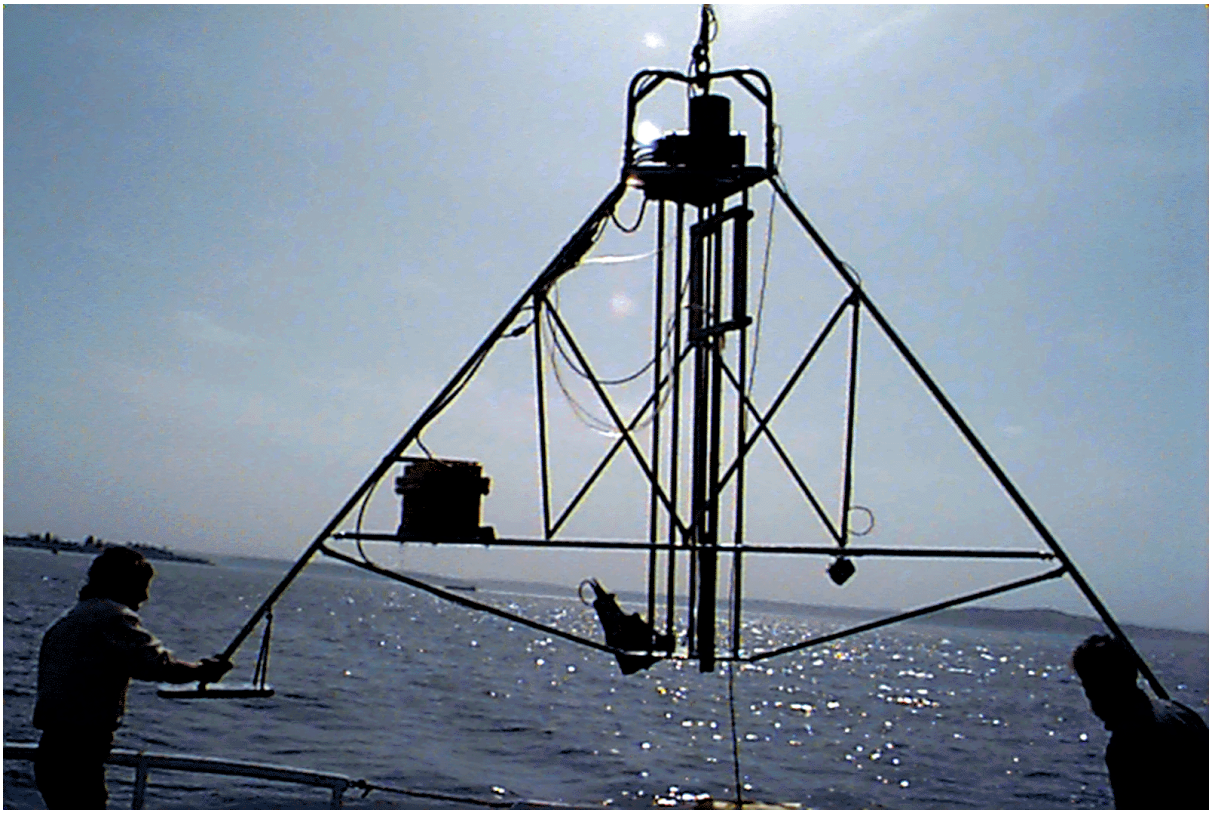
The net results of the 1998 field test was that the UW sand probe is a working instrument, capable of providing in situ physical property data in a variety of shallow water sediment environments. During these field tests, we used a borrowed video system, which proved to be essential during the deployments. We plan to purchase our own video system and integrate it into the tripod real-time data link for future deployments. Several software problems uncovered during the 1998 deployment are under active repair and will be tested in our field tests in April/May of 1999. We have completed several safety tests using a borrowed radioactive Ce-137 source, and are in the process of purchasing our own 15 mCurie source for the density probe. Prior to the July, 1999, DRI field program in Panama City, the entire UW sand probe system will undergo final tests during two cruises in Puget Sound, currently scheduled for April and May of 1999.

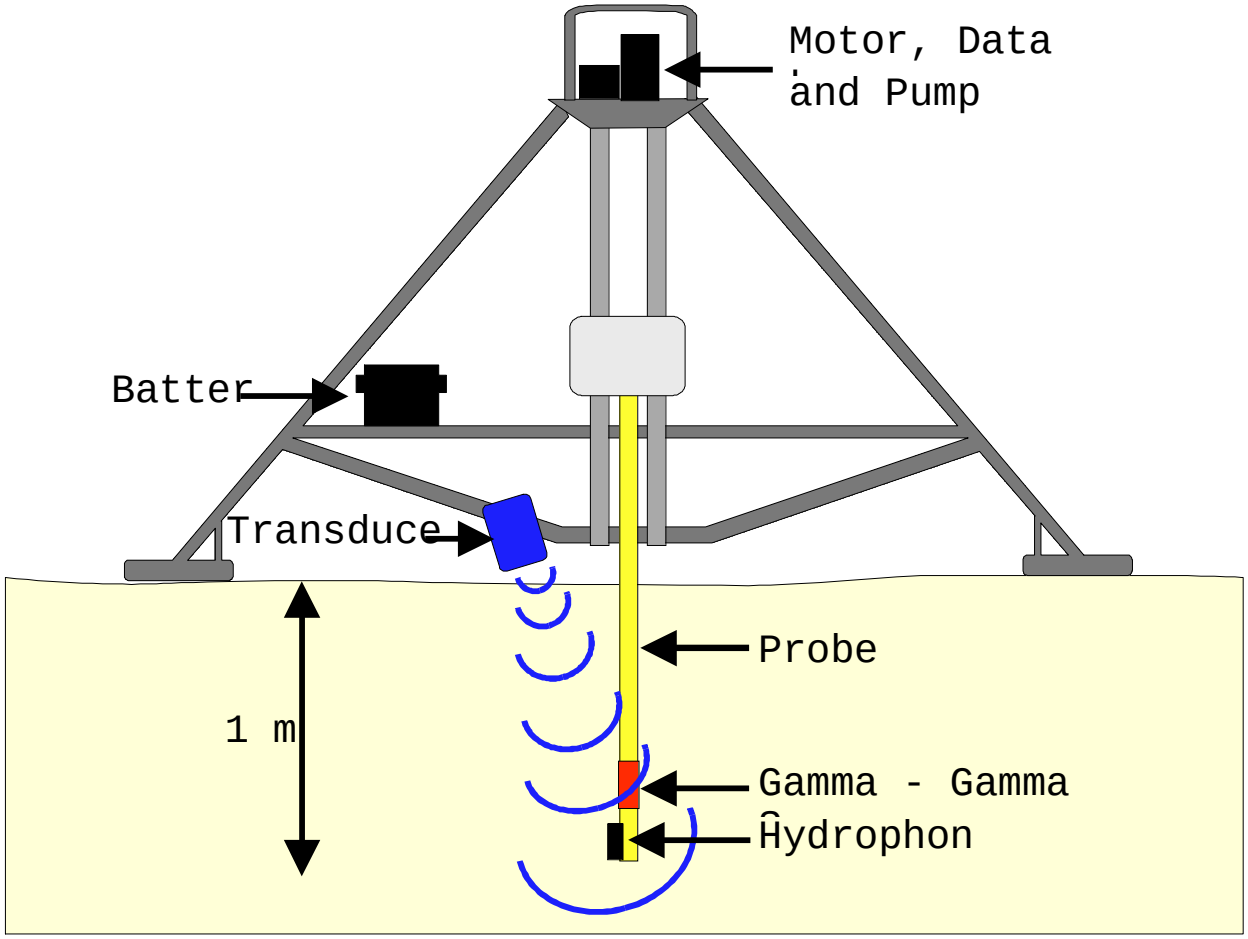
IMPACT/APPLICATION

The suite of physical property data from the UW tripod will further the goals of ONR/DRI program by providing direct measurement of both the absolute values and the spatial variability of the relevant parameters at the proposed survey sites. This will allow the high resolution test area for the subsequent September field program to located at the best possible site; within uniform sandy sediment with a smooth upper surface. The UW tripod measurements are done rapidly, and can be conducted on a regional (kilometer-long survey lines) scale.

TRANSITIONS

Equally important to providing site-survey data for the high resolution component of the DRI is the exciting possibility of integrating the large scale physical property measurements from the UW sand probe with the other studies that are being conducted within the experiment. These multi-discipline studies at a wide range of scales (from acoustic pathlengths that are tens of meters long to lab studies at electron microscope scales) will allow us to define the chemical, physical and biological processes that influence sediment properties.

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